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| Applicant: | Jong Dam KIM et al. | Conf.: | 6627 |
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| For: | METHOD AND APPARATUS FOR TESTING FLAT PANEL DISPLAY | | |

LETTER TO EXAMINER

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

APR - 7 2005

Sir:

Further to the Amendment filed February 22, 2005, please find attached a verified English translation of the priority document No. P2003-28643 in connection with the above-identified application.

The filing of the verified English translation of the priority document perfects priority over Kwon (U.S. Patent 6,566,902) such that the invention is patentable over any combination of Kwon under 35 U.S.C. § 103(c).

***Conclusion***

No issues remain. The Examiner is accordingly respectfully requested to place the application into allowance and to issue a Notice of Allowability.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Robert E. Goozner (Reg. No. 42,593) at the

telephone number of the undersigned below, to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or to credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

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JAK/REG/bsh
**2658-0310P**

Attachment

# STATUTORY DECLARATION

I, Sun Suk KIM, a citizen of the Republic of Korea and a staff member of Y.H.KIM INTERNATIONAL PATENT & LAW OFFICE specializing in "METHOD AND APPARATUS FOR INSPECTING FLAT PANEL DISPLAY DEVICE", do hereby declare that:

I am conversant with the English and Korean languages and a competent translator thereof.

To the best of my knowledge and belief, the following is a true and correct translation of the Priority Document (No. P2003-28643) in the Korean language already filed with Korean Industrial Property Office on May 6, 2003.

Signed this 25th day of February, 2005

Sun Suk KIM

# PATENT APPLICATION

**DOCUMENT NAME**: PATENT APPLICATION

**TO**: COMMISSIONER

**DATE**: May 6, 2003

**TITLE OF THE INVENTION:**

**APPLICANT(S):** LG. Philips LCD Co., Ltd.

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The present application is filed pursuant to Article 42 of the Korea Patent Act.

Patent Attorney

Young Ho KIM

## ABSTRACTS

**[Abstract]**

This invention relates to a method and an apparatus for inspecting badness of a wire and a pixel of a flat panel display device by using a magnetic sensor.

In the method and the apparatus for inspecting the flat panel display device, the magnetic sensor is scanned on at least one signal wire and a resistance change of the magnetic sensor is detected, so that it is possible to sense a short of the signal wire.

**[Representative drawing]**

FIG. 10

## SPECIFICATION

**[Title of the invention]**

METHOD AND APPARATUS FOR INSPECTING FLAT PANEL DISPLAY DEVICE

**[Brief description of the drawings]**

FIG. 1 is a perspective view illustrating a device for electrically inspecting a liquid crystal display of the related art.

FIG. 2 is a plane view illustrating one example of a pattern badness of a pixel electrode.

FIG. 3 is a cross sectional view illustrating a giant magneto-resistance sensor GMR.

FIG. 4 is a graph illustrating a hysteresis curve characteristic of a GMR sensor.

FIG. 5 is a cross sectional view illustrating a magnetization direction of a GMR sensor when an external electric field is applied.

FIG. 6 is a cross sectional view illustrating a magnetization direction of a GMR sensor when an external electric field does not exist.

Fig. 7 is a circuit diagram illustrating a resistance detector connected to a GMR sensor.

FIG. 8 is a graph illustrating a relation of a magnetization state of a GMR sensor and a resistance.

FIG. 9 illustrates a method and apparatus for inspecting a flat panel display device according to a first embodiment of the present invention.

FIG. 10 is a plane view illustrating a scribing line SCRL.

FIG. 11 is a cross sectional view illustrating a magnetization direction of a GMR sensor when a current flows in a signal wire shown in FIG. 9.

FIG. 12 is cross sectional view illustrating a

magnetization direction of a GMR sensor when a current does not flow in a signal wire shown in FIG. 9.

FIG. 13 illustrates a scan method on a substrate before a scribing process with respect to a method and apparatus for inspecting a flat display device according to a first embodiment of the present invention.

FIG. 14 illustrates a method and apparatus for inspecting a flat display device according to a second embodiment of the present invention.

FIG. 15 is a cross sectional view illustrating a magnetization direction of a GMR sensor when a current flows in a signal wire shown in FIG. 14.

FIG. 16 is a cross sectional view illustrating a magnetization direction of a GMR sensor when a current does not flow in a signal wire shown in FIG. 14.

FIG. 17 illustrates a scan method on a substrate before a scribing process with respect to a method and apparatus for inspecting a flat display device according to the second embodiment of the present invention.

FIG. 18 illustrates a method and apparatus for inspecting a flat display device according to a third embodiment of the present invention.

FIGs. 19Aa and 19B illustrate a movement of a sensor array shown in FIG. 18.

<Detailed description of the reference numerals>

1 : a substrate of GMR sensor
2 : a fixed layer of GMR sensor
3 : a hard magnetic layer of GMR sensor
4 : a non-magnetic layer of GMR sensor
5 : a soft magnetic layer of GMR sensor
7 : a hysteresis curve of hard magnetic layer
8 : a hysteresis curve of soft magnetic layer
10 : a modulator
11 : a substrate to be tested
12 : an upper transparent substrate of modulator

13 : a common electrode

14 : a polymer-dispersed liquid crystal (PDLC)

15 : a lower transparent substrate of modulator

16 : a reflection sheet

19 : a thin film transistor (TFT)

41 : a magnetization direction of hard magnetic layer

42 : a magnetization direction of soft magnetic layer

51a, 51b : an electrode of GMR sensor

52, 172 : a resistance detector

93a, 93b, 134, 136 : an inspection pad

94a, 94b, 135, 137 : a shorting wire

95, 139 : a shored point

97 : an insulation layer

98 : an inspection data common pad

99 : an electrostatic discharge damage(ESD) device

100 : an ESD shorting line

156, 111 : a substrate of flat panel display device

157 : an insulation layer

171 : a sensor array

200 : a GMR sensor

20, PIX(1,1) to PIX(2,3), 175 : a pixel electrode

921 to 92n, 1321 to 132n, 1331 to 133n : a signal pad

17, 18, 31a, 31b, 32a, 32b, 32c, 901 to 90n, 1301 to 130n, 1311 to 131m, 173, 174 : a signal wire

**[Detailed description of the invention]**

**[Object of the invention]**

**[Technical field including the invention and prior art therein]**

The present invention relates to a flat display device, and more particularly to a method and an apparatus for inspecting badness of a wire and a pixel of a flat panel display device by using a magnetic sensor.

In recent, an importance of a display apparatus is enlarged as a visual information transfer medium. A cathode ray tube is used widely at present, but has a defect that a

weightness and a volume are large. Therefore there has been developed various types of a flat panel display apparatus capable of overcoming the defect of the cathode ray tube.

There are a liquid crystal display (LCD), a field emission display (FED), a plasma display panel (PDP) and a electro-luminescence (EL) as the flat display apparatus and most of these apparatuses are available in a market.

The liquid crystal display apparatus is adaptive for smallness and its productivity is improved. Thus, it fast replaces the cathode ray tube in many applications.

Specially, the liquid crystal display apparatus of an active matrix type driving a liquid crystal cell by using a thin film transistor (hereinafter referred to as "TFT") has an advantage of an excellent picture quality and a low power consumption. It has rapidly been developed into a large volume and a high definition due to a recent productivity technology and research.

A process for fabricating the liquid crystal display apparatus of the active matrix type is divided into a substrate cleaning, a substrate patterning, an alignment forming/rubbing, a substrate assembling/a liquid crystal material injecting, a mounting, a inspecting and a repairing.

The impurity on a substrate surface of the liquid crystal display apparatus is removed by a detergent during the substrate cleaning process.

The substrate patterning process is divided into a patterning of an upper substrate, i.e., a color filter substrate and a patterning of a lower substrate, i.e., TFT array substrate. There are formed a color filter, a common electrode and a black matrix on the upper substrate. Signal wire such as a data line and a gate line is formed on the lower substrate, and the TFT is formed at an intersection of the data line and the gate line, and a pixel electrode is formed in a pixel region between the gate line and the data line connected to a source electrode of the TFT.

An alignment film is applied to each of the upper substrate and the lower substrate in the alignment film forming/rubbing process and the alignment film is rubbed by a rubbing material.

In the substrate assembling/the liquid crystal injection process, both of the upper substrate and the lower substrate are bonded together by using a sealant, and the liquid crystal material and a spacer are injected through a liquid crystal injection hole and then liquid crystal injection hole is sealed.

In the mounting process of the liquid crystal panel, a tape carrier package (hereinafter referred to as "TCP") having integrated circuits mounted thereon such as a gate drive integrated circuit and a data drive integrated circuit is connected to a pad part on the substrate. Such drive integrated circuits may be directly mounted on the substrate by using a chip on glass (hereinafter referred to as "COG") method other than a TAB (Tape Automated Bonding) using the TCP described above.

The inspecting process includes first electrical inspection being performed after forming a variety of signal wires and the pixel electrode, and an electrical inspection and a visual inspection being performed after the substrate assembly/liquid crystal injection process. Specifically, the electrical inspection of the signal wire and the pixel electrode of the lower substrate followed by the substrate assembling may reduce a bad ratio and a waste matter and may find a bad substrate reparable in an early stage, and thus its importance is gradually increased.

The repairing process performs a restoration for a repairable substrate determined by the inspecting process. However, in the inspecting process, a badness substrates beyond repair are discarded.

The electrical inspection being performed before the substrate assembling frequently employs a method using an apparatus shown in FIG. 1.

Referring to FIG. 1, the electrical inspection process is performed as follows: separating a modulator 10 over a substrate 11 to be tested by a designated gap and applying a test voltage (Vtest) to the modulator while maintaining the gap and detecting a light reflected from the modulator 10 to determine an electrical badness of the signal wires 17 and 18.

In the modulator 10, a polymer-dispersed liquid crystal (hereinafter referred to as "PDLC") is located between an upper transparent substrate 12 having a common electrode 13 formed thereon and the lower transparent substrate 15. In the modulator 10, a reflection sheet 16 is set up toward a rear surface of the lower transparent substrate 15. The modulator 10 has an air nozzle and a vacuum nozzle for an auto-gapping, which maintain the designated interval from the substrate 11 to be tested.

A lens 21 for light-focusing the light from a light source (not shown) into the modulator 10 and in addition transmitting the light 22 reflected from the modulator 10 is installed on the modulator 10.

The substrate 11 to be tested comprises the lower substrate having the TFT 19 thereon, the signal wires 17 and 18 and the pixel electrode 20 formed in the liquid crystal display apparatus of the active matrix type.

The electrical inspection is begun by loading the substrate 11 to be tested below the modulator 10 and then descending the modulator while performing the auto-gapping. While maintaining the gap between the modulator 10 and the substrate 11 to be tested as a predetermined effective gap, the light is radiated from the light source (not shown) and the light is focused on the modulator 10 by the light-gathering lens 21 and simultaneously the test voltage (Vtest) is applied to the common electrode 13. And the test data applied from a zig driving circuit is applied to the data wires 17 and a test scan signal is applied to the gate wires 18. Then, an effective electric field is applied to

the PDLC 14 between the common electrode 13 of the modulator 10 and the pixel electrode 20 to be tested.

The PDLC 14 causes the light scattered when the electric field is not applied and the liquid crystal within the liquid crystal bell is arranged to the direction of the effective electric field (E) to cause the light to be transmitted when the effective electric field (E) is applied. Accordingly, in the electrical inspection process, when the voltage is normally applied to the pixel electrode 20, the liquid crystal layer of the PDLC 14 corresponding to the pixel electrode 20 causes the light 22 to be transmitted, and when the voltage is not applied to the pixel electrode 20, the liquid crystal layer of the PDLC 14 causes the light to be scattered in that part.

While the light 22 transmitting the liquid crystal layer of the PDLC 14 is reflected on the reflection sheet 16 and then is reversely directed to a light path, the light 22 scattered in the liquid crystal layer of the PDLC 14 is nearly vanished and is not nearly incident to the reflection sheet 16. The light reflected in the modulator 10 is received to a charge-coupled device (CCD) (not shown) via the lens 21 and then is converted in an electrical signal. And, the converted signal is transferred to a display apparatus (not shown) via a signal processing circuit. A testing inspector monitors an image or data displayed in the display apparatus to determine whether bad or not and secondarily performs a close inspection about the signal wires 17 and 18 of doubtable point.

By the way, the modulator 10 represents an advantage of an exactness and a reliability capable of inspecting whether bad or not of the pixel by pixel but has a defect of high price. Further, since the inspection region is narrow as compared with total area of the substrate 11, the modulator 10 repeats the process of transferring by a designated length to a vertical or a horizontal direction and then stopping temporarily for auto-gapping. Thus, there

is a defect that the inspection time is needed very much. Further, an exactness of the modulator 10 with respect to the high fineness of the flat display device is lower than desiring value. For example, as shown in FIG. 2, if it is assumed that a portion of the first column and the second row of the pixel electrode PIX (1,2) among the pixel electrodes PIX (1,1) to PIX (2,3) formed in the pixel region between the data wires 32a, 32b and 32c and the gate wires 31a and 31b is lost due to a pattern badness, when a test scan voltage is applied to the gate wire 31a and simultaneously a test data voltage is applied to the data wire 32b, since the test data voltage is supplied to the first column and the second row of the pixel electrode PIX (1,2) via the TFT (not shown), an electric field is generated between the pixel electrode PIX (1,2) and the common electrode 13 of the modulator 10 as in normal pixel. As a result, since a reflecting light is collected to the charge-coupled device via the modulator 10 in the pixel corresponding to the first column and second row of the pixel electrode PIX(1,2), the pixel is determined as a normal.

**[Technical Subject Matter to be solved by the Invention]**

Accordingly, it is an object of the present invention to provide a method and an apparatus for inspecting badness of a wire and a pixel of a flat panel display device by using a magnetic sensor.

**[Configuration and Operation of the Invention]**

In order to achieve these and other objects of the invention, a method of inspecting a flat panel display device according to a first embodiment of the present invention includes: scanning one or more signal wires by using a magnetic sensor; and detecting a resistance change of the magnetic sensor to perceive a short of the signal wire.

The step of perceiving the short of the signal wire includes: detecting the resistance of the magnetic sensor depending on the change of current flowing in the magnetic sensor; and determining the short of the signal wire if the resistance of the magnetic sensor is larger than a designated reference value.

The method according to the first embodiment of the present invention further includes applying different voltages to the adjacent signal wires.

The step of applying the different voltages to the adjacent signal wires includes: applying a first common voltage to one side of odd-numbered signal wires; and applying a second common voltage different from the first common voltage to one side of even-numbered signal wires.

A method of inspecting a liquid crystal display device according to a second embodiment of the present invention includes: scanning one of more second signal wires stacked on at least one of first signal wires as putting an insulation layer therebetween by using a magnetic sensor; and detecting a resistance change of the magnetic sensor to perceive an interlayer short between the first and the second signal wires.

The step of perceiving an interlayer short between the first and second signal wires includes: detecting the resistance of the magnetic sensor depending on a change of a current flowing in the magnetic sensor; and determining the short of the first and second signal wires if the resistance of the magnetic sensor is larger than a designated reference value.

The method according to the second embodiment of the present invention further includes: applying a first common voltage to one side of the first signal wires; and applying a second common voltage different from the first common voltage to one side of the second signal wires.

In the method according to the first and the second embodiments of the present invention, the magnetic sensor

scans the second signal wire on the pads connected to the other side of the second signal wire.

In the method according to the first and the second embodiments of the present invention, the magnetic sensor includes a hard magnetic layer and a soft magnetic layer and wherein the magnetization direction of the soft magnetic layer is changed by an induced magnetic field from the first and second signal wires.

The step of perceiving the interlayer short between the first and second signal wires includes determining the short of the signal wire when a primary magnetization direction of the soft magnetic layer is inverted.

A method of inspecting a liquid crystal display device according to a third embodiment of the present invention includes: scanning an electrode pattern by using a sensor array including one of more magnetic sensors below a pixel in size; and detecting the resistance change of each of the magnetic sensors to perceive the badness of the electrode pattern.

The step of detecting the resistance change of the magnetic sensor includes: detecting the resistance of the each of the magnetic sensors with the change of the current flowing to each of the magnetic sensors; and determining the short of a portion of the electrode pattern at the location where the resistance of the magnetic sensor is larger than designated reference value.

The method according to the third embodiment of th present invention further includes applying current to the electrode pattern.

The method according to the third embodiment of the present invention further includes the magnetic sensor includes a hard magnetic layer and a soft magnetic layer, wherein the magnetization direction of the soft magnetic layer is changed by an induced magnetic field from the signal wire.

The step of detecting the resistance change of each of

the magnetic sensors includes determining that the electrode pattern is lost when the incipient magnetization direction of the soft magnetic layer is returned to the incipient magnetization direction at the location where the electrode pattern is lost after inverting by the induced magnetic field from the electrode pattern where the current flows.

An apparatus of inspecting a flat panel display device according to the first embodiment of the present invention includes: a magnetic sensor for scanning one or more signal wires; and a detecting circuit for detecting the resistance change of the magnetic sensor to perceive a short of the signal wire.

The apparatus according to the first embodiment of the present invention further includes a voltage source for supplying different voltages to the adjacent signal wires.

The voltage source includes: a first voltage source for supplying a first common voltage to one side of odd-numbered signal wires; and a second voltage source for supplying a second common voltage different from the first common voltage to one side of even-numbered signal wires.

An apparatus of inspecting a liquid crystal display device according to the second embodiment of the present invention includes: a magnetic sensor for scanning on at least one second signal wire stacked on at least one first signal wire wherein an insulation layer is located between the first signal and the second signal wires; and a detecting circuit for detecting a resistance change of the magnetic sensor to perceive an interlayer short of the signal wires.

The apparatus according to the second embodiment of the present invention further includes: a first voltage source for supplying a first common voltage to one side of the first signal wires; and a second voltage source for supplying a second common voltage different from the first common voltage to one side of the second signal wires.

An apparatus of inspecting a liquid crystal display device according to the third embodiment of the present invention includes: a magnetic sensor including at least one magnetic sensor below a pixel in size for scanning on an electrode pattern; and a detecting circuit for detecting a resistance change of each of the magnetic sensors to perceive a pattern badness of the electrode pattern.

The apparatus according to the third embodiment of the present further includes the voltage source for supplying a current to the electrode pattern.

In the apparatus of inspecting the flat panel display device according to the first to the third embodiments of the present invention, The apparatus according to claim 19, the magnetic sensor comprises one of a giant magneto-resistance sensor, a magneto-resistance sensor, a tunneling magneto-resistance sensor, a fluxgate sensor and an inductive sensor.

In the apparatus of inspecting the flat panel display device according to the first to the third embodiments of the present invention, the detecting circuit detects the resistance of the magnetic sensor with the change of the current flowing to the magnetic sensor.

Hereinafter, the preferred embodiments of the present invention will be described in detail with reference to FIGs. 3 to 18B.

A method and apparatus for inspecting a flat panel display device according to an embodiment of the present invention inspects a badness of signal wires and pixel electrodes of a flat display device by using a magnetic sensor such as a GMR(a giant magneto-resistance) sensor, a MR(a magneto-resistance) sensor, a TMR(a tunneling magneto-resistance) sensor, a fluxgate sensor and an inductive sensor. The following description will be made with respect to the GMR sensor of these magnetic sensors.

Referring to FIG. 3, the GMR sensor comprises a fixed layer 2, a hard magnetic layer 3, a non-magnetic layer 4

and a soft magnetic layer 5 stacked on the substrate 1.

The fixed layer 2 serves to fix a magnetization direction or magnetic spin momentum of the hard magnetic layer 3.

The hard magnetic layer 3 is comprised of a magnetic material of which a saturated magnetic field is large such as Co. The magnetization characteristic of the hard magnetic layer 3 is inverted when an external magnetic field H and an induced magnetic field M are widely changed as in a hysteresis curve 7 shown in FIG. 4.

The non-magnetic layer 4 is comprised of non-magnetic material such as Cu and cuts off a magnetic interference between the hard magnetic layer 3 and the soft magnetic layer 5.

The soft magnetic layer 5 is comprised of a magnetic material of which a saturated magnetic field is small such as NiFe. The magnetization characteristic of the soft magnetic layer 5 is inverted although there is a little change in the external magnetic field H and the induced magnetic field M as in a hysteresis curve 8 shown in FIG. 4.

If the external magnetic field H enough to magnetize the hard magnetic layer 3 is applied to the a GMR sensor as shown in FIG. 5, the hard and the soft magnetic layers become to be magnetized in the direction of the external magnetic field H. In this connection, the magnetization directions 41 and 42 of the hard magnetic layer 3 and the soft magnetic layer 5 are arranged in the direction of the external magnetic field H.

As depicted in FIG. 6, if the external magnetic field H is removed in a state that the hard magnetic layer 3 and the soft magnetic layer 5 of the GMR sensor are magnetized, the magnetization direction 41 of the hard magnetic layer 3 is restricted by the fixed layer 2 to maintain in the direction when the external magnetic field H is applied. However, the magnetization direction 42 of the soft magnetic layer 5 with a low saturated magnetic field is

arranged in the opposite direction to the external magnetic field H by an antiferromagnetic coupling. That is, if the external magnetic field H is removed, the magnetization direction 42 of the soft magnetic layer 3 is arranged in the opposite direction to the external magnetic field H.

As shown in FIG. 7, after the electrode 51a and 51b are formed in both sides of the GMR sensor and the resistance detecting circuit 52 is connected to the electrode 51a and 51b, as shown in FIGs. 5 and 6, if the external magnetic field H is applied to the GMR sensor or is removed, the resistance detected by the resistance detecting circuit 52 occurs differently in accordance with the presence or the absence of the external magnetic field H.

The resistance detecting circuit 52 makes the current flow between the electrodes 51a and 51b formed in both sides of the GMR sensor and detects the current depending on the current change. As shown in FIG. 5, when the external magnetic field H is applied, in a spin parallel state SPS where in the magnetization direction 41 and 42 of the hard magnetic layer 3 and the soft magnetic layer 5 are arranged in the external magnetic field H, a low resistance value R is detected in the resistance detecting circuit R as shown in FIG. 8. However, as shown in FIG. 6, in a spin antiparallel state SAS where in the external magnetic field H is removed and the magnetization direction 42 of the soft magnetic layer 5 is inverted, a high resistance value R is detected in the resistance detecting circuit R as shown in FIG. 8.

The method and apparatus of inspecting the flat panel display device according to the embodiment of the present invention determines a signal wire badness and a pixel electrode badness of the flat panel display device by using the resistance change of the GMR sensor.

Referring to FIG. 9, there is shown the method and apparatus of inspecting the flat display device according

to the first embodiment of the present invention. According to the present invention, a high common voltage Vh is supplied to one side of odd-numbered signal wires 901, 903,…, 90n-1 while a low common voltage Vl is supplied to one side of even-numbered signal wires 902, 904,…, 90n and pads 921 to 92n connected to other side of each of the signal wires 901 to 90n are scanned to inspect a short of the signal wires 901 to 90n.

The signal wires 901 to 90n comprise scan signal wires (or gate wires or row wires) or data signal wires (or column wires).

The odd-numbered signal wires 901, 903,…, 90n-1 are connected to a first shorting wire 94a in one side and are shorted mutually and maintain an electrical insulation with even-numbered signals 902, 904,…, 90n. The first shorting wire 94a is connected to a first inspection pad 93a to which a high common voltage Vh is supplied. The even-numbered signal wires 902, 904,…, 90n are connected to a second shorting wire 94b in one side and are shorted mutually and maintain an electrical insulation with odd-numbered signals 901, 903,…, 90n-1. The second shorting wire 94b is connected to a second inspection pad 93b to which a low common voltage Vl is supplied.

Upon inspecting the short on the signal wires 901 to 90n, the GNR sensor scans along the pads 921 to 92n connected to each of the signal wires 901 to 90n with non-contacting method. As shown in FIG. 11, if it is assumpted that the second and the third signal wires 902 and 903 are shorted by an impurity or a pattern badness caused in the manufacturing process, the current i does not flow in the first signal wire 901 and the fourth to the Nth signal wires 904 to 90n, while the current i flows via a shorted point 95 in the second and the third signal wires 902 and 903. At this time, the current i flows from the third signal wire 903 to the second signal wire 902 since the high voltage Vh is applied to the odd-numbered signal

wiries 901, 903,..., 90n-1 and the low voltage Vl is applied to the even-numbered signal wires. Then, as shown in FIG. 10, the current i flows between the second signal wire 902 and the third signal wire 903 and the induced magnetic field M is induced to the GMR sensor 200 and the current i flows in the GMR sensor 200 by the induced magnetic field M. On the other hand, as shown in FIG. 12, since the current i does not flow in the first signal wire 901 and the fourth to the Nth signal wires 904 to 90n, the magnetic field is not applied to the GMR sensor 200.

The resistance detector 52 connected to both sides of the GMR sensor 200 detects the resistance R depending on the current flowing in the GMR sensor 200. The resistance R detected when the GMR sensor 200 scans the second and the third signal wires 902 and 903 is detected by a smaller value than a designated reference value since the magnetization directions 41 and 42 of the hard magnetic layer and the soft magnetic layer of the GMR sensor 200 are arranged by the same direction as the induced magnetic field M. On the other hand, the resistance R detected when the GMR sensor 200 scans the first signal wire 901 and the fourth to the Nth signal wires 904 to 90n is detected by a larger value than a designated reference value since the magnetization direction 42 of the soft magnetic layer of the GMR sensor 200 is inverted.

The resistance value detected by the resistance detector 52 is converted into a digital signal by a signal processing circuit(not shown), is amplified and then is displayed on the monitor under control of a control circuit and a monitor driving circuit, which are not shown. Accordingly, the inspection perceiving sees the resistance value displayed on the monitor and thereby knows the short of the second and the third signal wires 902 and 903.

As shown in FIG. 10, after the inspection process, the inspection pads 93a and 93b and the shorting wires 94a and 94b are separated from the TFT array in the scribing

process. Upon the scribing process, the substrate is cut off along a scribing line SCRBL crossing the signal pads 96 and 97. In FIG. 10, a reference numeral '96' is a scan signal pad connected to the scan signal wire and a reference numeral '97' is a data pad connected to the data wire crossing the scan signal wire. And a reference numeral '98' is an inspection data common pad for supplying a data voltage to the data wires in the inspection process and a reference numeral '99' is a device for protecting an electrostatic discharge damage (hereinafter referred to as "ESD protection device"). One terminal of the ESD protection device is connected to the data wire or the scan signal wire and the other terminal is connected to a ESD shorting line 100 to which a ground voltage GND or common voltage is supplied. When a static electricity is arisen in the TFT array upon the manufacturing process or normal driving, the ESD protection device bypasses, the static electricity to the ESD shorting line 100 to thereby protect the TFT array from the static electricity.

As shown in FIG. 13, the short inspection on the signal wires 901 to 90n can be collectively carried out with respect to the substrate having a plurality of TFT arrays formed thereon before being subjected to scribing process. In this case, the GMR sensor 200 scans in the scan direction SCD crossing the pads, each of which respectively connected to the signal wires 901 to 90n, to detect the current and the resistance.

FIGs. 14 to 17 are diagrams illustrating the method and apparatus for inspecting the flat panel display device according to the second embodiment of the present invention which show an inspection method when the signal wires formed in different layers are shorted, respectively.

Referring to FIG. 14, the method and apparatus for inspecting the flat panel display device according to the second embodiment of the present invention supplies the high common voltage Vh to one side of the data signal wires

1311 to 131m and supplies the low common voltage Vl to one side of the scan signal wires (or gate wire or row wire) 1301 to 130n crossing the data signal wires (or column wire) 1311 to 131m.

The data signal wires 1311 to 131m are connected to the first shorting wire 137 in one side. The first shorting wire 137 is connected to the first inspection pad 136 to which the high common voltage Vh is supplied.

The scan signal wires 1301 to 130n are connected to the second shorting wire 135 in one side. The second shorting wire 135 is connected to the second inspection pad 134 to which the low common voltage Vl is supplied.

After the inspecting process, the inspection pads 134 and 136 and the shorting wires 135 and 137 are separated from the TFT array in the scribing process as shown in FIG. 10.

If the flat panel display device is a liquid crystal display device, the TFTs are formed in each of the intersections of the data signal wires 1311 to 131m and the scan signal wires 1301 to 130n. When the scan voltage higher than its own threshold voltage is applied, the TFT is turned-on to supply the data voltage on the data signal wires 1311 to 131m to the pixel electrode 138.

And the method and apparatus for inspecting the flat panel display device according to the second embodiment of the present invention scans the data signal wires 1311 to 131m on the pads 1331 to 133m connected to the other side of the data signal wires 1311 to 131m by using the GMR sensor 200 and scans the scan signal wires 1301 to 130n on the pads 1321 to 132n connected to the other side of the scan signal wires 1301 to 130n by using GMR sensor 200 and inspects an interlayer short between signal wires 1311 to 131m, and 1301 to 130n formed on the different layer.

As in FIGs. 15 and 16, the insulation layers 157 are formed between the data signal wires 1311 to 131m and the scan signal wires 1301 to 130n.

Upon inspecting the interlayer short between the data signal wires 1311 to 131m and the scan signal wires, the GMR sensor 200 scans by non-contacting method along the scan direction SCD crossing the scan signal pads 1321 to 132n and then scans by non-contacting method along the scan direction SCD crossing the data pads 1331 to 133m. Alternatively, the GMR sensor may scan by non-contacting method along the data pads 1331 to 133m and then scans by non-contacting method along the scan signal pad 1321 to 132n.

In the location where the data signal wires 1311 to 131m and the scan signal wires 1301 to 130n are crossed the data signal wires 1311 to 131m and the scan signal wires 1301 to 130n are shorted since the insulation layer 97 is lost due to the badness of the deposition process or the patterning process. As shown in FIG. 14, if the third data signal wire 1313 and the second scan signal wire 1302 are shorted, because the low common voltage Vl is supplied to the scan signal wires 1301 to 130n and the high common voltage Vh is supplied to the data signal wires 1311 to 131m, the current i flows between the third data signal wire 1313 and the second scan signal wire 1302 via the short point 139. The current i flows from the third data signal wire 1313 to the second scan signal wire 1302. If the current flows as described above, the induced magnetic field M is induced to the GMR sensor 200 and thus the current flows by the induced magnetic field M when the GMR sensor 200 scans the third data pad 1333 and the second scan signal pad 1322 as shown in FIG. 15. The lower resistance R than the designated reference value is detected since the magnetization direction 41 and 42 of the hard magnetic layer and the soft magnetic layer of the GMR sensor 200 in the resistance detector 52 is arranged with the same direction as the induced magnetic field M.

On the other hand, although the low common voltage Vl is applied to the scan signal wires 1301 to 130n and the

high common voltage Vh is applied to the data signal wires 1311 to 131m, the current i does not flow, if there is no short point 139 between the first, the second, the fourth to the Mth data signal wires 1311, 1312, 1314 to 131m and the first, the third to the Nth scan signal wires 1301, 1303 to 130n, as shown in FIG. 16. Then, when the GMR sensor 200 scans the first, the second, the fourth to the Mth data pads 1331, 1332, 1334 to 133m and the first, the third and the Nth scan signal pads 1321, 1323 to 132n, the resistance R higher than the designated reference value is detected since the induced magnetic field M is not induced to the GMR sensor 200 and since the magnetization direction 42 of the soft magnetic layer of the GMR sensor 200 in the resistance detector 52 is inverted.

If the current i or the resistance R is detected when the GMR sensor 200 scans the data pads 1331 to 133m and the current i or if the resistance R is detected when the GMR sensor 200 scans the scan signal pads 1321 to 132n, the exact location where the interlayer short point 139 exists can be detected.

The resistance value detected by the resistance 52 is converted into a digital signal, is amplified by the signal processing circuit 53 and then is displayed on the monitor under control of the control circuit and the monitor driving circuit, which are not shown. Accordingly, the inspection operator perceives the resistance value displayed on the monitor and can detect the interlayer short between the data signal wires 1311 to 131m and the scan signal wires 1301 to 130n.

The inspection of the interlayer short between the data signal wires 1311 to 131m to the scan signal wires 1301 to 130n, as shown in FIG. 17, can be collectively carried out respect to the substrate having a plurality of TFT array formed thereon before being subjected to the scribing process. In this case, the GMR sensor 200 scans to the scan direction SCD proceeding along the data signal

wires 1311 to 131m and the scan signal wires 1301 to 130n to detect the current and the resistance.

FIGs. 18 to 19B are diagrams illustrating the method and apparatus for inspecting the flat panel display device according to a third embodiment of the present invention which represent the method and apparatus inspecting a badness of the pixel electrode, respectively.

Referring to FIG. 18, the method and apparatus for inspecting the flat panel display device according to the third embodiment of the present invention comprises a sensor array 171 including a plurality of GMR sensors G1 to Gn.

The GMR sensors G1 to Gn are patterned, which are below the pixel in size. The N numbers of GMR sensors G1 to Gn patterned minutely below the size of the pixel in the sensor array 171 are disposed in a row. The sensor array 171 scans in an arrow direction in an arranged state in which the GMR sensors G1 to Gn are disposed in parallel with the data signal wires 174. Each of the GMR sensors G1 to Gn supplies to the resistance detector 172 a current signal detected from the scan signal wires 173, the data signal wires 174 and the pixel electrode 175. The resistance detector 172 detects the resistance R depending on the current detected from each of the GMR sensors G1 to Gn of the sensor array 171.

As shown in FIGs. 19A and 19b, the first GMR sensor G1 and the Nth GMR sensor Gn of the sensor array 171 may be used in the short inspection of the scan signal wires 173, and the first to the Nth sensors G1 to Gn of the sensor array 171 may be used in the short inspection of the data signal wires 174. Further, the third to the (N-2)th GMR sensors G3 to Gn-2 of the sensor array 171 may be used in the pattern badness of the pixel electrode 175. Since the above description is made to the short inspection on the signal wires 173 and 174, the following description will be made to the embodiment of the inspection on the pattern

badness of the pixel electrode 175.

A current is applied to the pixel electrode 175 via the TFTs (not shown) and the data signal wires 174 as similar to the electro luminescence EL display device upon inspecting on the pattern badness of the pixel electrode 175.

When the sensor array 171 scans in the arrow direction in a state that the current is supplied via the data signal wire 174 in the pixel electrode 175, the induced magnetic field M is induced from the pixel electrode 175 in the third to the (N-2)th GMR sensors G3 to Gn-2 of the sensor array 171 if the sensor array 171 reaches at the location of the FIG. 19A. Accordingly, as shown in FIG. 19A, the third to the (N-2)th GMR sensors G3 to Gn-2 detect the current i and the resistance detector 172 detects the resistance R less than the designated reference value by the current i detected from the GMR sensors G3 to Gn-2.

If the sensor array 17 moves further to the arrow direction at the location of the FIG. 19A to reach at the location of the FIG. 19B, the induced magnetic field M is not induced in the third while the fourth GMR sensors G3 and G4 of the sensor array 171 and the induced magnetic field M is induced in the fifth to the (N-2)th GMR sensors G5 to Gn-2 due to the pattern loss of the pixel electrode 175. Accordingly, as shown in FIG. 19B, the fifth to the (N-2)th GMR sensors G5 to Gn-2 scanned at the location where the pixel pattern exists detect the current i and the resistance detector 172 detects the resistance R less than the designated reference value by the current i detected from the GMR sensors G5 to Gn-2. On the other hand, the third and the fourth GMR sensors G3 and G4 scanned at the location where the pattern of the pixel electrode 175 is lost cannot detect the current i and the resistance detector 172 connected to the GMR sensors G3 and G4 detect the resistance R more than the designated reference value.

**[Effect of the Invention]**

As described above, the method and apparatus for inspecting the flat panel display device according to the invention detects the short of the signal wire, the short of the interlayer signal wire and the badness of the electrode pattern with the magnetic sensor to increase an inspection preciseness and an inspection speed.

Although the present invention has been explained by the embodiments shown in the drawings described above, it should be understood to the ordinary skilled person in the art that the invention is not limited to the embodiments, but rather that various changes or modifications thereof are possible without departing from the spirit of the invention. For example, though the method and apparatus that is capable of carrying out the electrical inspection on the short of the signal wire and the pattern badness by using the GMR sensor is explained, the short of the signal wire and the pattern badness like the embodiment can be inspected by using the magnetic sensor besides the GMR sensor, that is the fluxgate sensor, the inductive sensor, etc. Accordingly, the scope of the invention shall be determined only by the appended claims and their equivalents.

[What is claimed is:]

1. A method of inspecting a flat panel display device comprising:

scanning one or more signal wires by using a magnetic sensor; and

detecting a resistance change of the magnetic sensor to perceive a short of the signal wire.

2. The method according to claim 1, wherein the step of perceiving the short of the signal wire comprises:

detecting the resistance of the magnetic sensor depending on the change of current flowing in the magnetic sensor; and

determining the short of the signal wire if the resistance of the magnetic sensor is larger than a designated reference value.

3. The method according to claim 1, further comprising applying different voltages to the adjacent signal wires.

4. The method according to claim 3, wherein the step of applying the different voltages to the adjacent signal wires comprises:

applying a first common voltage to one side of odd-numbered signal wires; and

applying a second common voltage different from the first common voltage to one side of even-numbered signal wires.

5. The method according to claim 4, wherein the magnetic sensor scans the signal wire on pads connected to the other side of the signal wires.

6. The method according to claim 1, wherein the magnetic sensor includes a hard magnetic layer and a soft magnetic

layer, and wherein the magnetization direction of the soft magnetic layer is changed depending on a induced magnetic field from the signal wire.

7. The method according to claim 6, wherein the step of perceiving the short of the signal wire includes determining the short of the signal wire when a primary magnetization direction of the soft magnetic layer is inverted.

8. A method of inspecting a liquid crystal display device comprising:

scanning one of more second signal wires stacked on at least one of first signal wires as putting an insulation layer therebetween by using a magnetic sensor; and

detecting a resistance change of the magnetic sensor to perceive an interlayer short between the first and the second signal wires.

9. The method according to claim 8, wherein the step of perceiving an interlayer short between the first and second signal wires includes

detecting the resistance of the magnetic sensor depending on a change of a current flowing in the magnetic sensor; and

determining the short of the first and second signal wires if the resistance of the magnetic sensor is larger than a designated reference value.

10. The method according to claim 8, further comprising:

applying a first common voltage to one side of the first signal wires; and

applying a second common voltage different from the first common voltage to one side of the second signal wires.

11. The method according to claim 8, wherein the magnetic

sensor scans the second signal wire on the pads connected to the other side of the second signal wire.

12. The method according to claim 8, wherein the magnetic sensor includes a hard magnetic layer and a soft magnetic layer and wherein the magnetization direction of the soft magnetic layer is changed by an induced magnetic field from the first and second signal wires.

13. The method according to claim 12, wherein the step of perceiving the interlayer short between the first and second signal wires includes determining the short of the signal wire when a primary magnetization direction of the soft magnetic layer is inverted.

14. A method of inspecting a liquid crystal display device comprising:

scanning an electrode pattern by using a sensor array including one of more magnetic sensors below a pixel in size; and

detecting the resistance change of each of the magnetic sensors to perceive the badness of the electrode pattern.

15. The method according to claim 14, wherein the step of detecting the resistance change of the magnetic sensor includes:

detecting the resistance of the each of the magnetic sensors with the change of the current flowing to each of the magnetic sensors; and

determining the short of a portion of the electrode pattern at the location where the resistance of the magnetic sensor is larger than designated reference value.

16. The method according to claim 14, further comprising applying current to the electrode pattern.

17. The method according to claim 14, wherein the magnetic sensor includes a hard magnetic layer and a soft magnetic layer, wherein the magnetization direction of the soft magnetic layer is changed by an induced magnetic field from the signal wire.

18. The method according to claim 17, wherein the step of detecting the resistance change of each of the magnetic sensors includes determining that the electrode pattern is lost when the incipient magnetization direction of the soft magnetic layer is returned to the incipient magnetization direction at the location where the electrode pattern is lost after inverting by the induced magnetic field from the electrode pattern where the current flows.

19. An apparatus of inspecting a flat panel display device comprising:

a magnetic sensor for scanning one or more signal wires; and

a detecting circuit for detecting the resistance change of the magnetic sensor to perceive a short of the signal wire.

20. The apparatus according to claim 19, wherein the magnetic sensor comprises one of a giant magneto-resistance sensor, a magneto-resistance sensor, a tunneling magneto-resistance sensor, a fluxgate sensor and an inductive sensor.

21. The apparatus according to claim 19, wherein the detecting circuit detects the resistance of the magnetic sensor with the change of the current flowing to the magnetic sensor.

22. The apparatus according to claim 19, further

comprising a voltage source for supplying different voltages to the adjacent signal wires.

23. The apparatus according to claim 22, wherein the voltage source comprises:

a first voltage source for supplying a first common voltage to one side of odd-numbered signal wires; and

a second voltage source for supplying a second common voltage different from the first common voltage to one side of even-numbered signal wires.

24. The apparatus according to claim 23, wherein the magnetic sensor scans the signal wires on the pads connected to the other side of the signal wires.

25. An apparatus of inspecting a liquid crystal display device, comprising:

a magnetic sensor for scanning on at least one second signal wire stacked on at least one first signal wire wherein an insulation layer is located between the first signal and the second signal wires; and

a detecting circuit for detecting a resistance change of the magnetic sensor to perceive an interlayer short of the signal wires.

26. The apparatus according to claim 25, wherein the magnetic sensor comprises one of a giant magneto-resistance sensor, a magneto-resistance sensor, a tunneling magneto-resistance sensor, a fluxgate sensor and an inductive sensor.

27. The apparatus according to claim 25, wherein the detecting circuit detects the resistance of the magnetic sensor with the change of the current flowing to the magnetic sensor.

28. The apparatus according to claim 25, further comprising:

a first voltage source for supplying a first common voltage to one side of the first signal wires; and

a second voltage source for supplying a second common voltage different from the first common voltage to one side of the second signal wires.

29. The apparatus according to claim 25, wherein the magnetic sensor scans the first and second signal wires on the pads connected to the other side of the first and second signal wires.

30. An apparatus of inspecting a liquid crystal display device, comprising:

a magnetic sensor including at least one magnetic sensor below a pixel in size for scanning on an electrode pattern; and

a detecting circuit for detecting a resistance change of each of the magnetic sensors to perceive a pattern badness of the electrode pattern.

31. The apparatus according to claim 30, wherein the magnetic sensors comprises one of a giant magneto-resistance sensor, a magneto-resistance sensor, a tunneling magneto-resistance sensor, a fluxgate sensor and an inductive sensor.

32. The apparatus according to claim 30, wherein the detecting circuit detects the resistance of each of the magnetic sensors with the change of the current flowing to each of the magnetic sensors.

33. The apparatus according to claim 30, further comprising the voltage source for supplying a current to the electrode pattern.

FIG.1

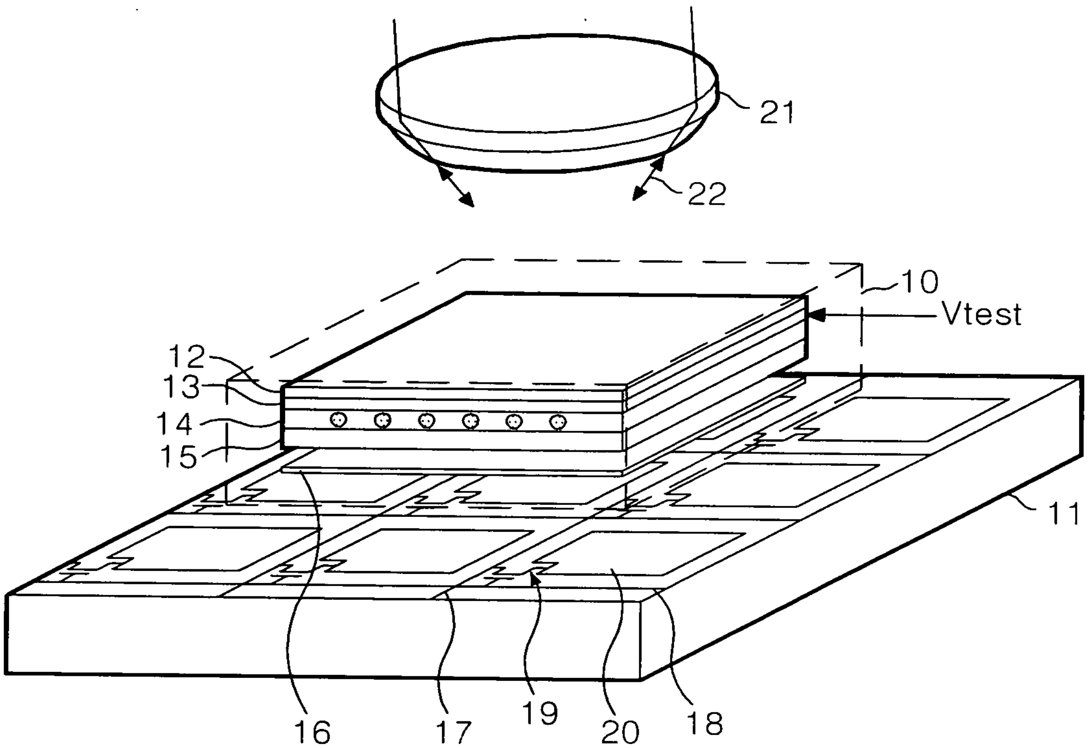
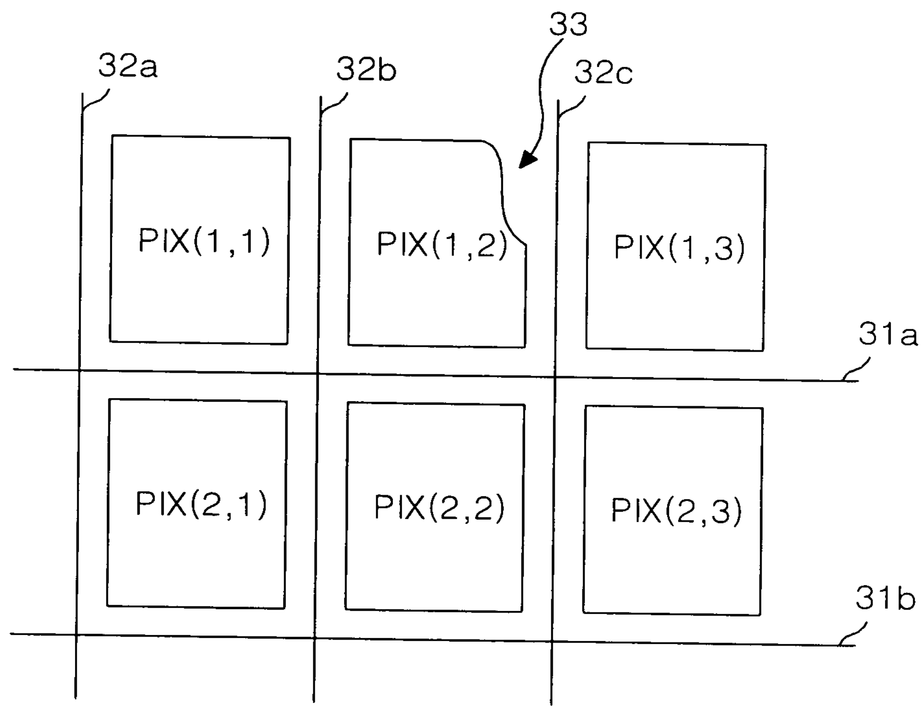
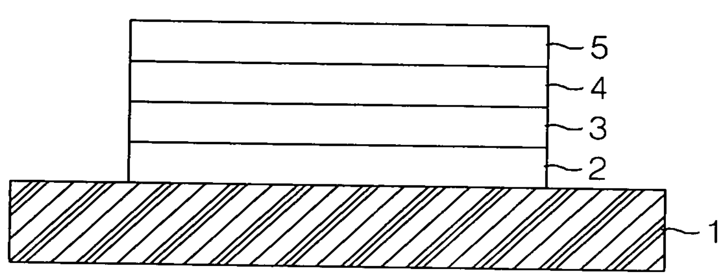


FIG.2



33
32a
32b
32c
PIX(1,1)
PIX(1,2)
PIX(1,3)
31a
PIX(2,1)
PIX(2,2)
PIX(2,3)
31b


FIG.3



5
4
3
2
1

FIG.4

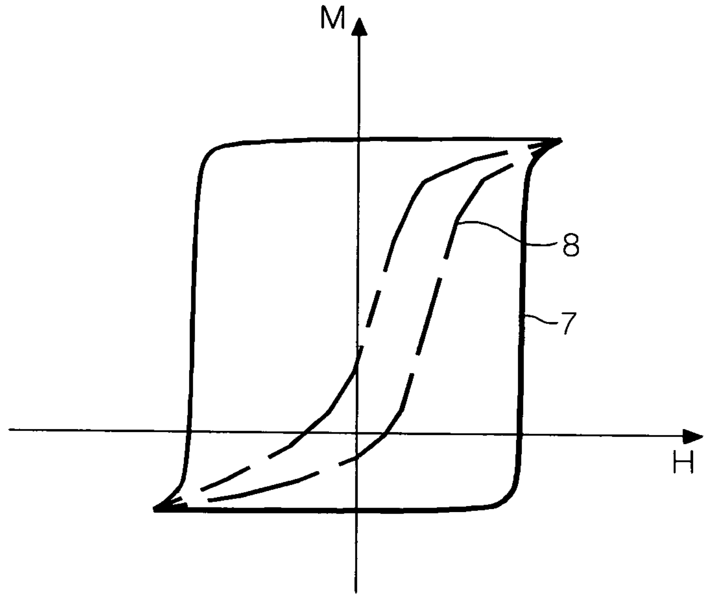



FIG.5

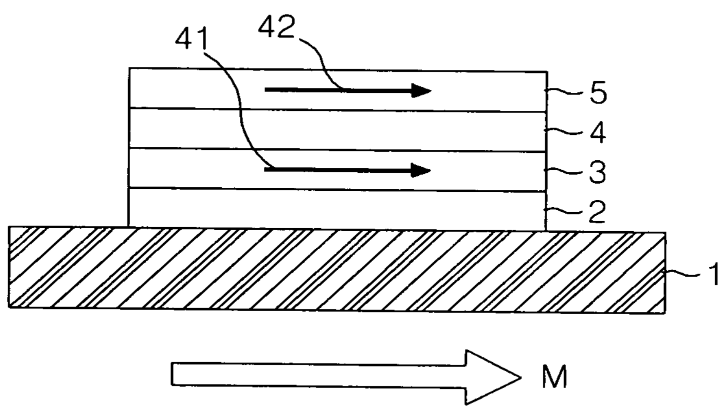


FIG.6

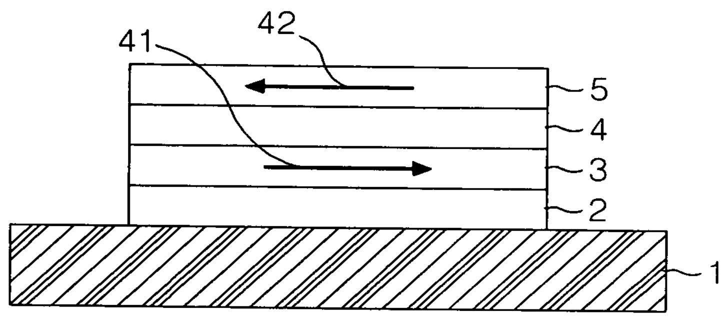



FIG.7

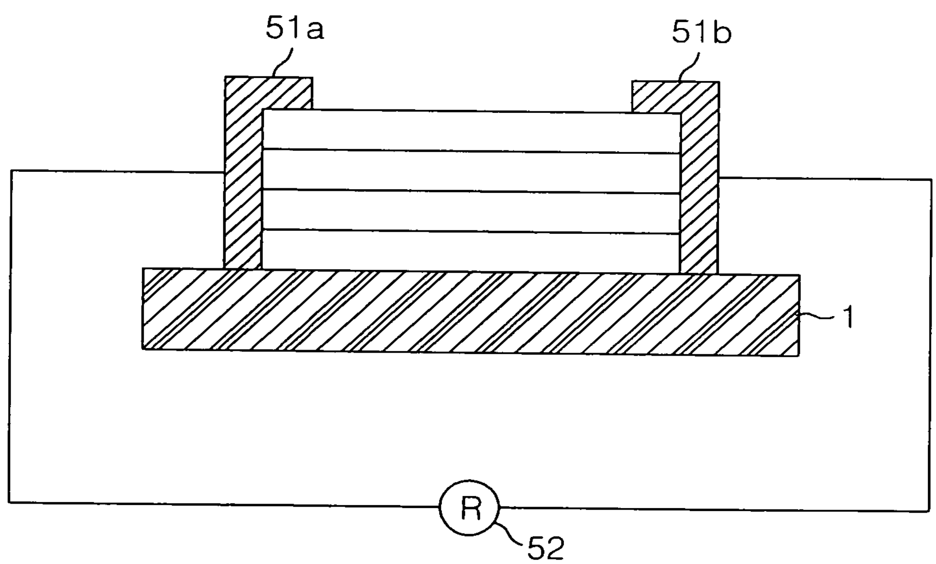


FIG.8

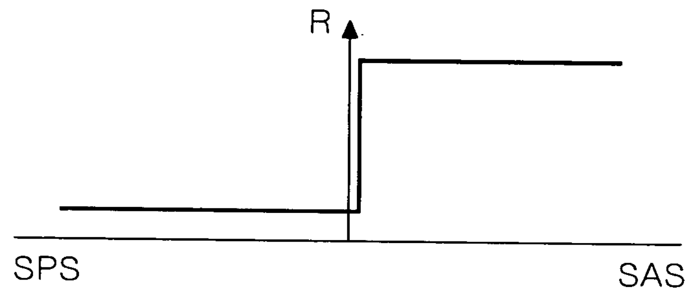


FIG.9

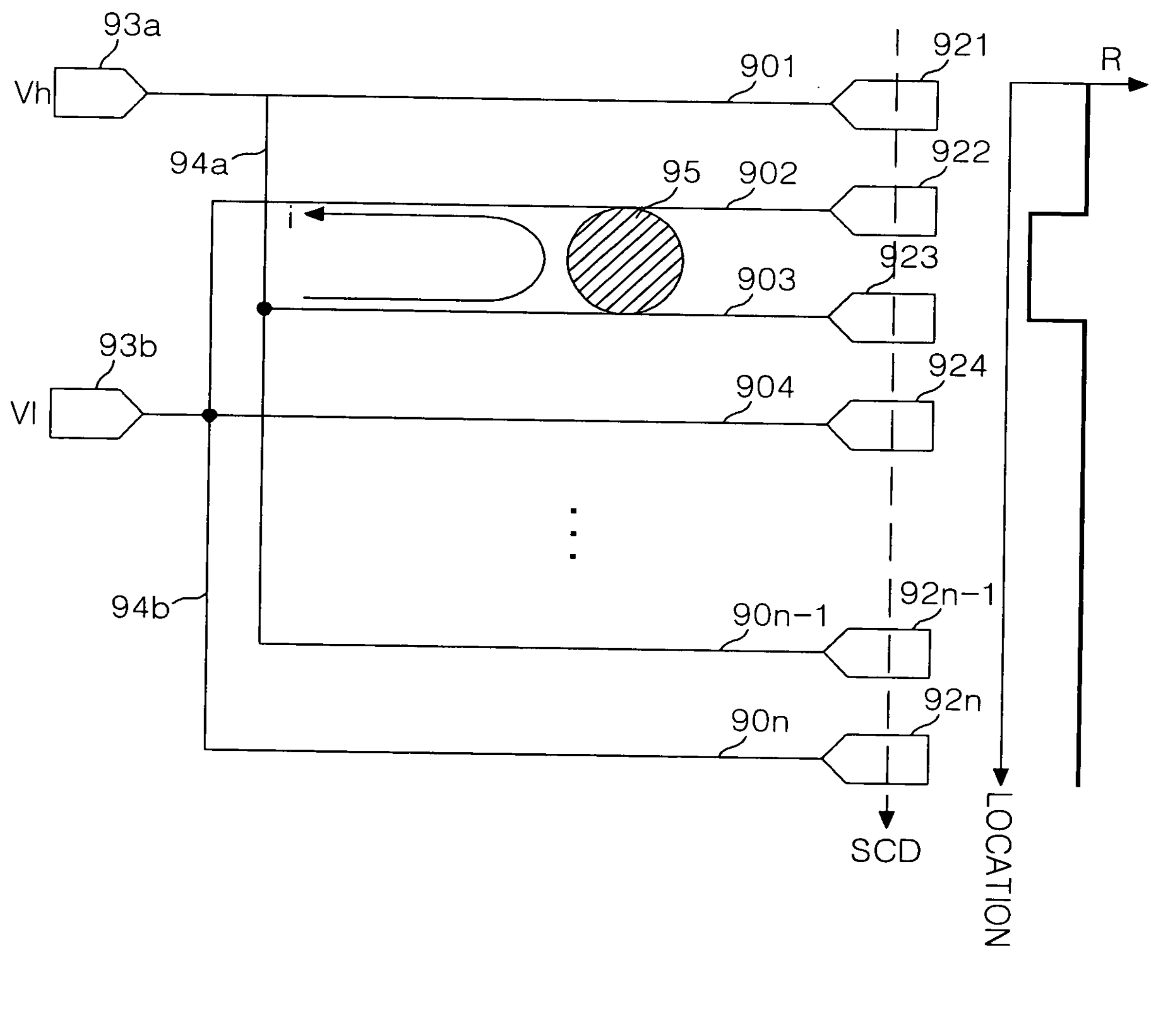

93a
Vh
901
921
R
94a
95
902
922
i
903
923
93b
Vl
904
924
94b
90n-1
92n-1
90n
92n
SCD
LOCATION

FIG. 10

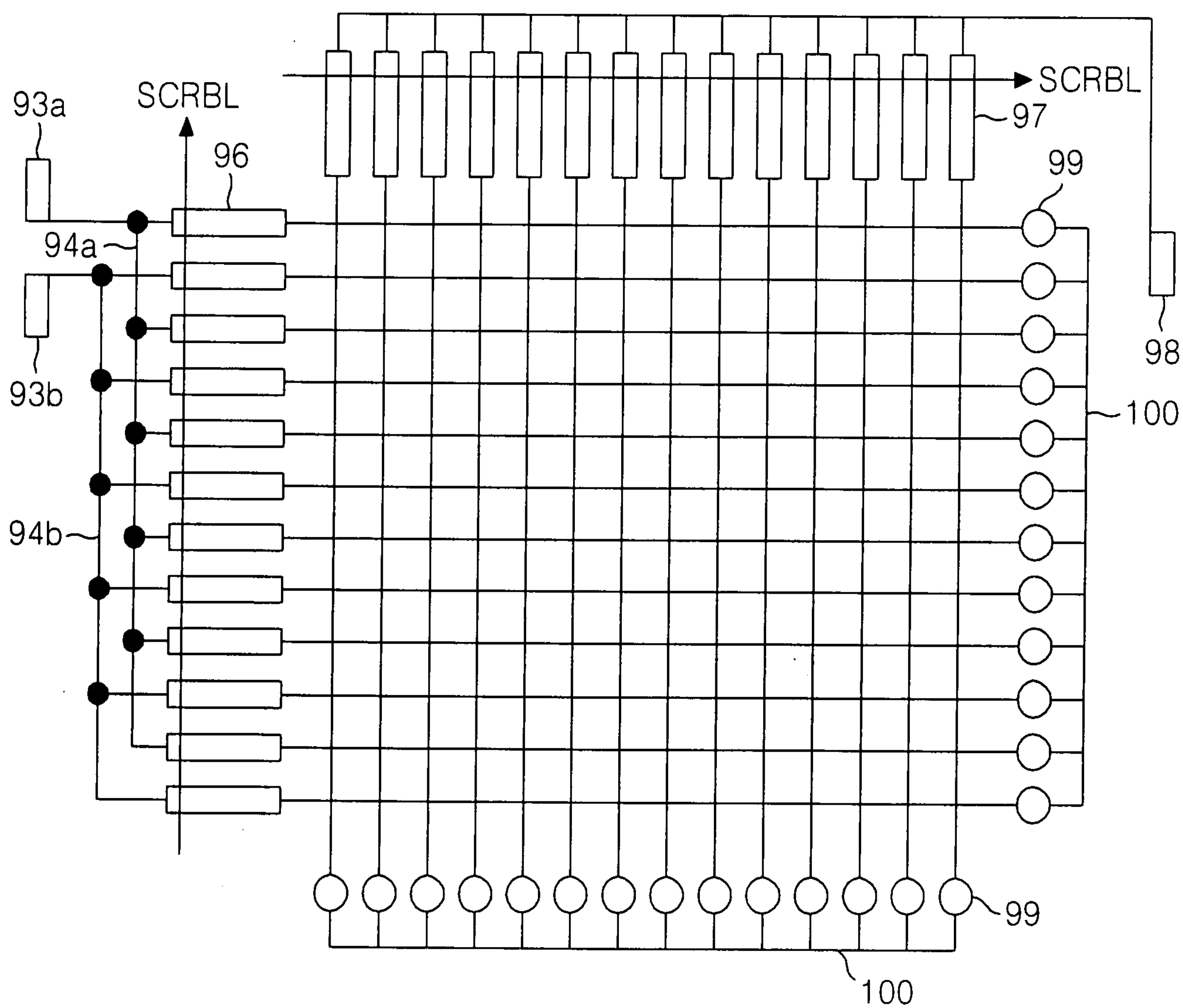


FIG.11

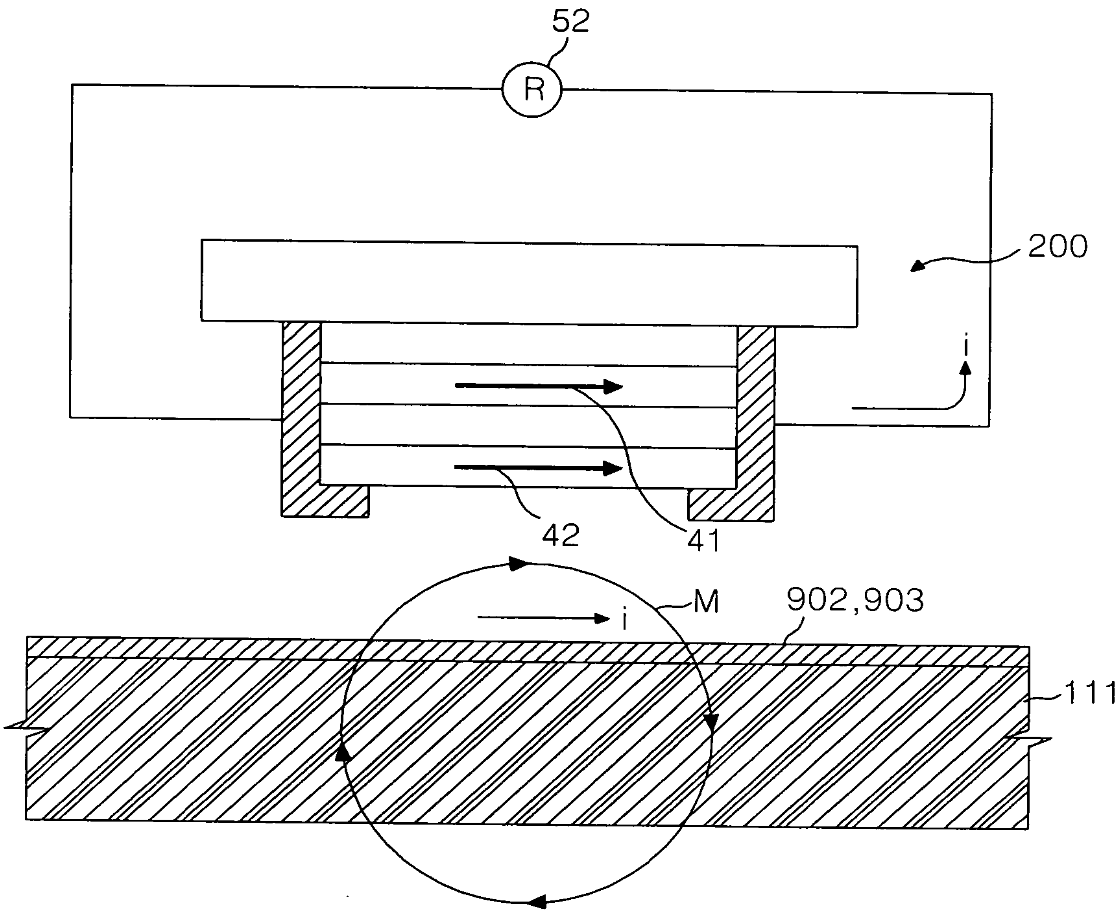


FIG.12

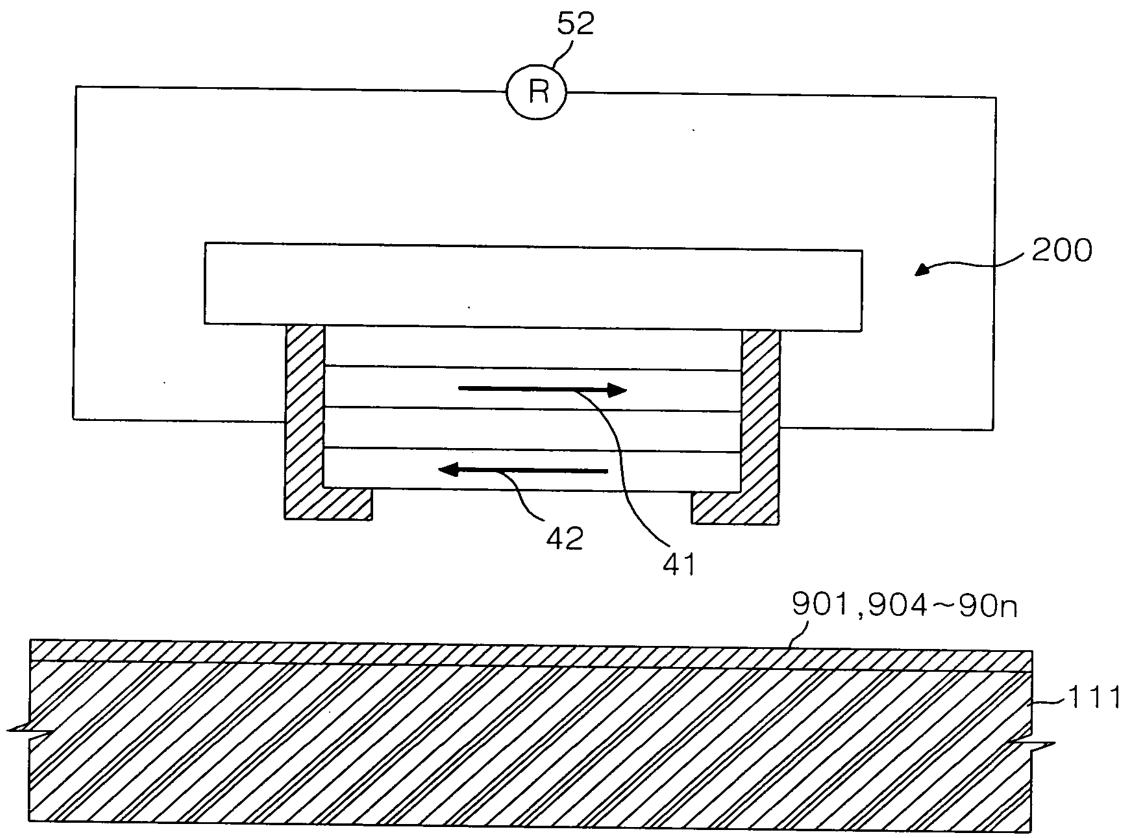


FIG.13

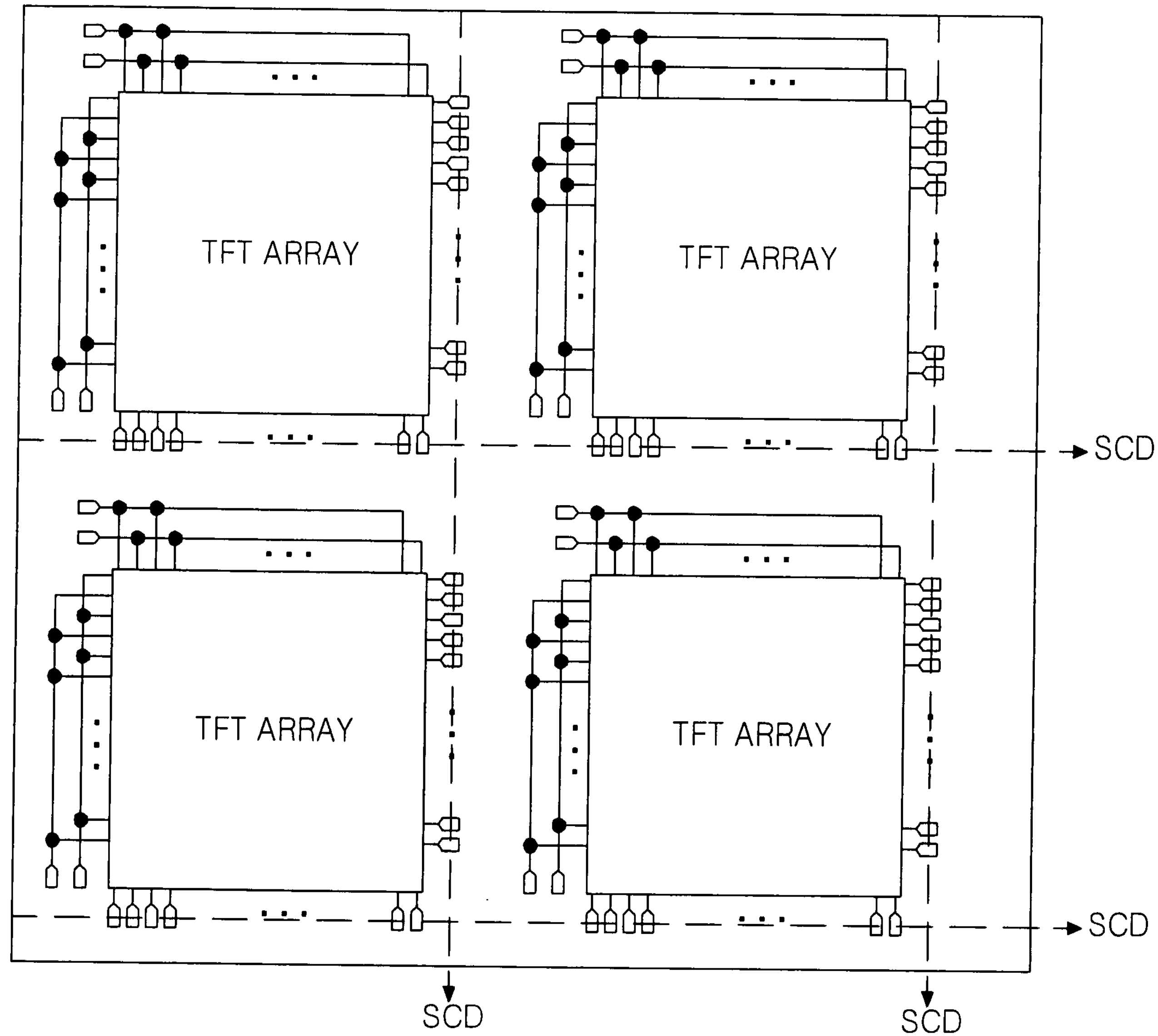
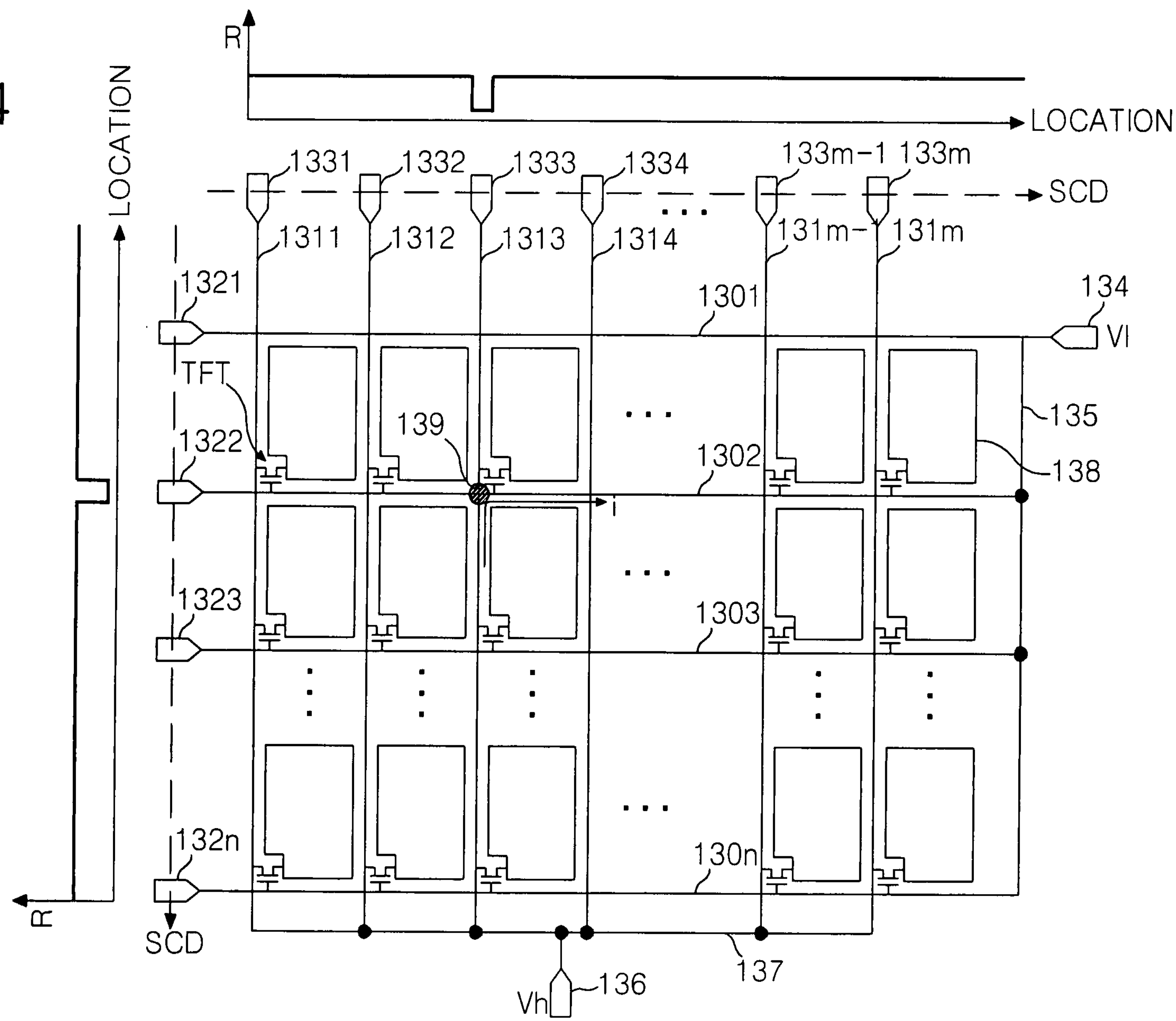


FIG.14



R
LOCATION
1331
1332
1333
1334
133m-1
133m
SCD
1311
1312
1313
1314
131m-1
131m
1321
1301
134
VI
TFT
135
139
1322
1302
138
i
1323
1303
132n
130n
R
SCD
137
Vh
136

FIG.15

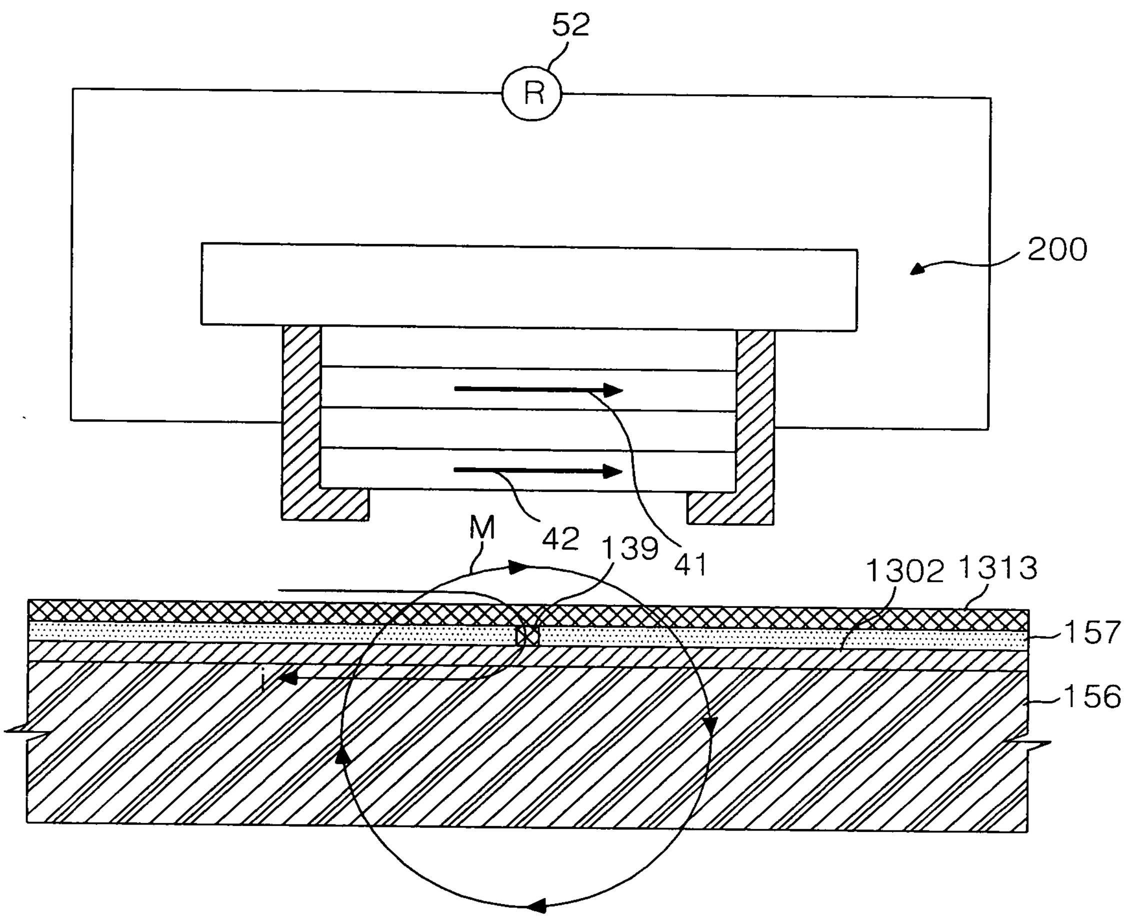


FIG.16

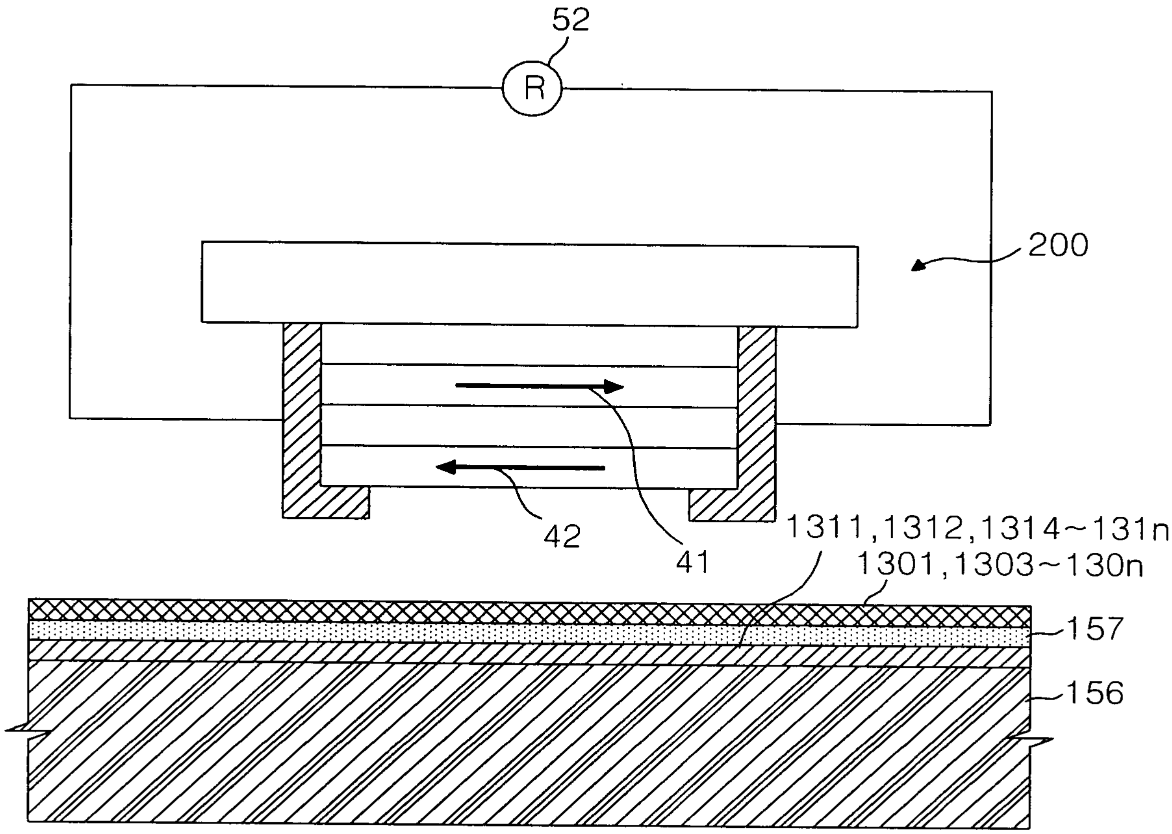


FIG.17

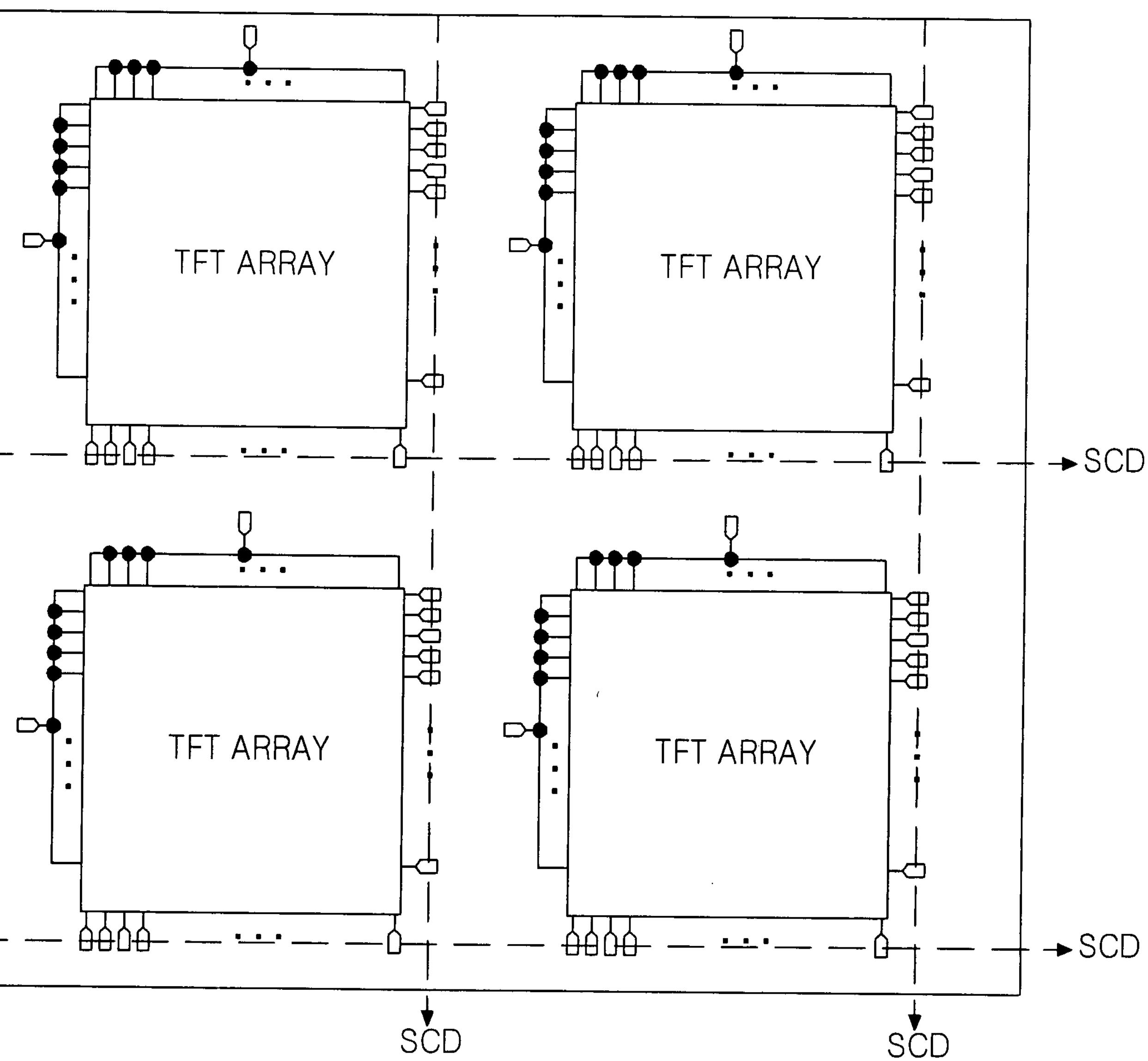
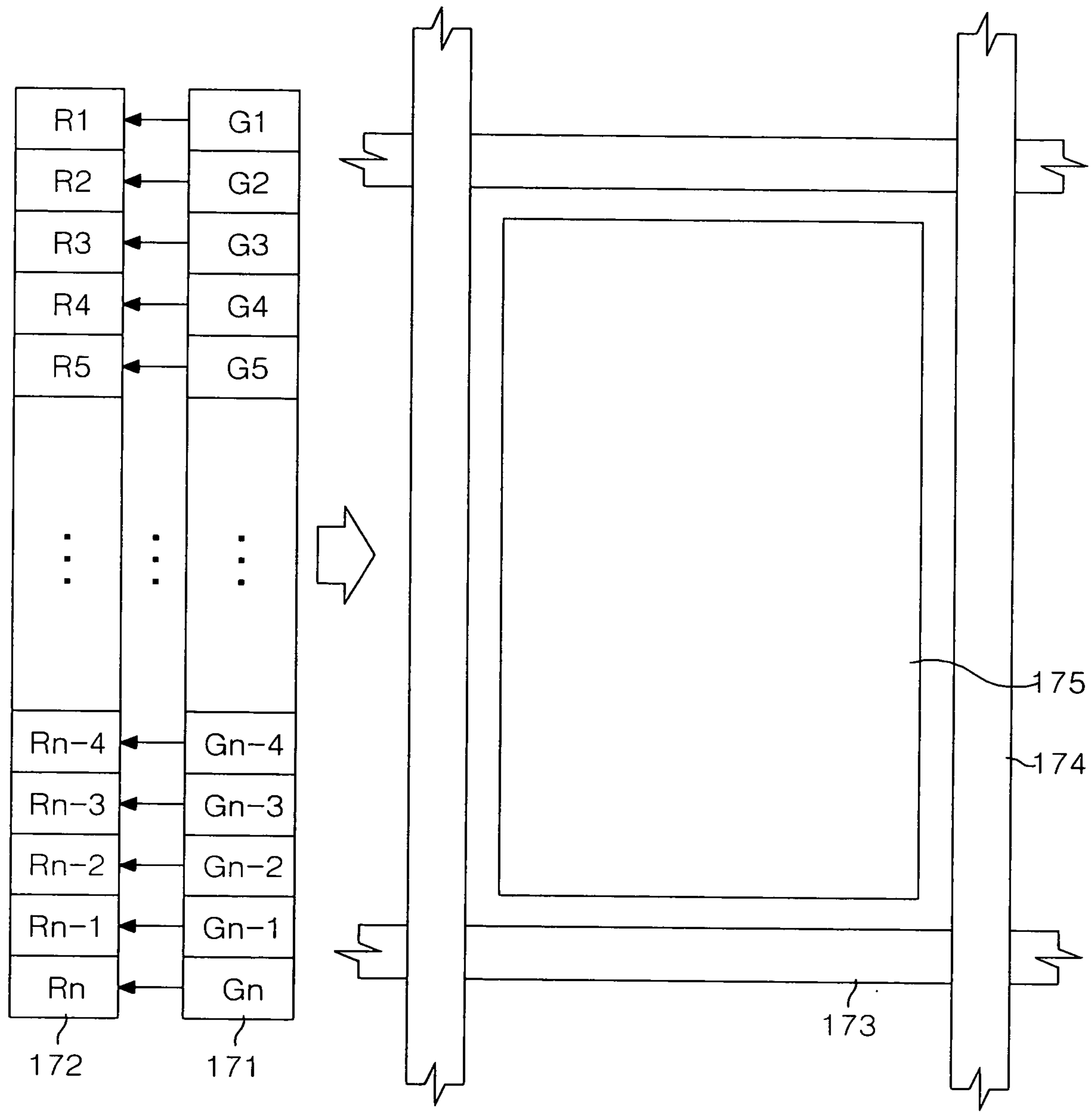


FIG.18



R1
R2
R3
R4
R5
Rn-4
Rn-3
Rn-2
Rn-1
Rn
G1
G2
G3
G4
G5
Gn-4
Gn-3
Gn-2
Gn-1
Gn
172
171
175
174
173

FIG.19A

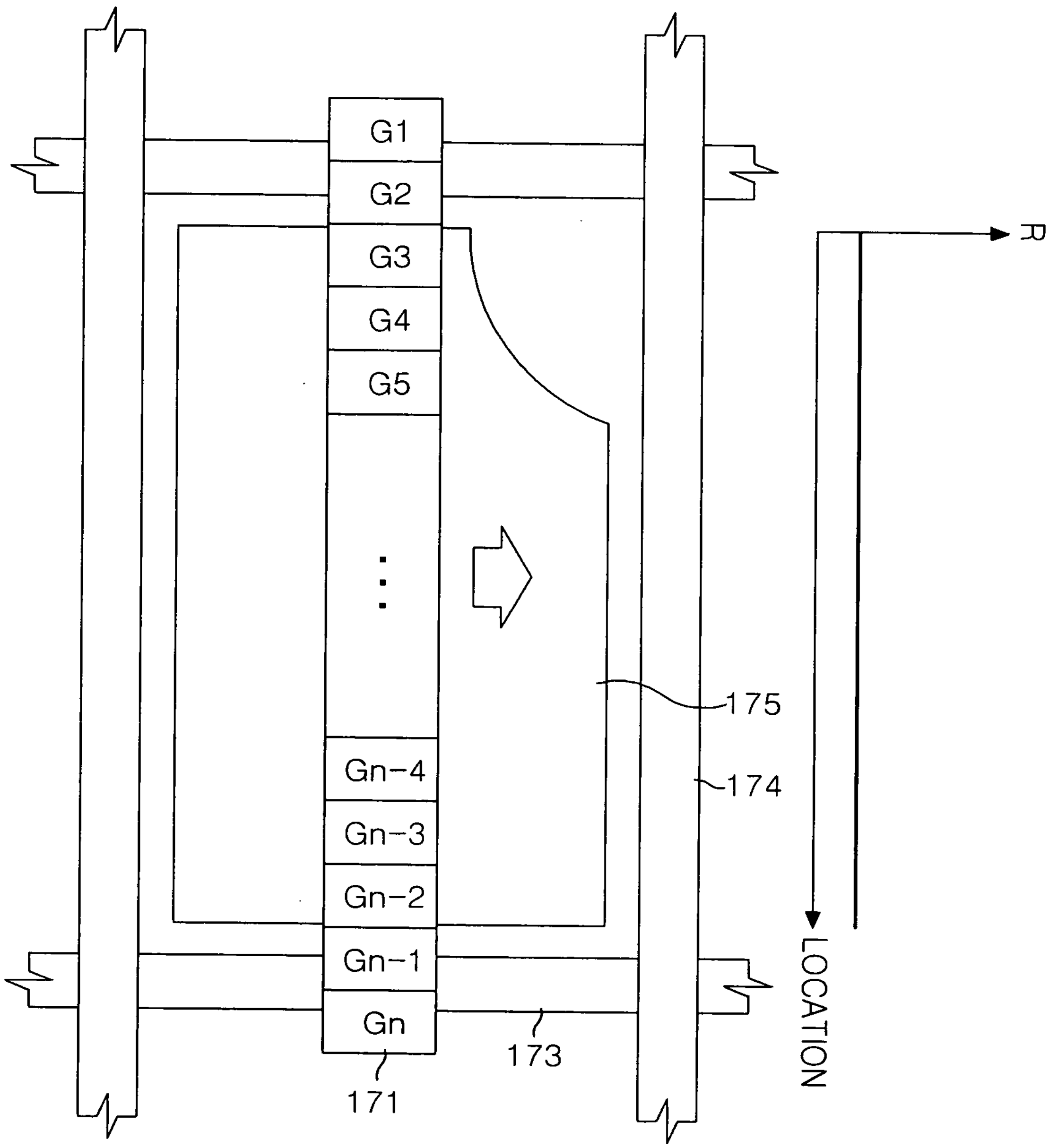


FIG.19B